

CLAIMS

What is claimed is:

1        1. A method for reducing the contact resistance of  
2           metal silicide contacts comprising the steps  
3           of:

5           (a) forming a metal germanium alloy layer over  
6           a silicon-containing substrate, wherein said  
7           metal is Co, Ti, Ni or mixtures thereof;

9           (b) annealing said metal germanium alloy layer  
10          at a temperature sufficient to convert at least  
11          a portion of said metal germanium alloy layer  
12          into a metal silicide layer that is  
13          substantially non-etchable compared to the  
14          unreacted metal germanium alloy layer, while  
15          forming a Si-Ge interlayer between said  
16          silicon-containing substrate and said  
17          substantially non-etchable metal silicide  
18          layer;

20          (c) removing any remaining metal germanium  
21          alloy layer, with the proviso that when Ti or  
22          Co are employed a second annealing step follows  
23          step (c) that is capable of converting the  
24          substantially non-etchable Ti or Co silicide  
25          phase into Co disilicide or C54 phase of  $TiSi_2$ .

1        2. The method of Claim 1 further comprising pre-  
2           annealing the metal germanium alloy layer prior

3                   to step (b) at a temperature sufficient to form  
4                   a metal rich germanium silicide layer.

1                   3.       The method of Claim 1 wherein said metal  
2                   germanium alloy layer is formed by a deposition  
3                   process selected from the group consisting of -  
4                   chemical vapor deposition (CVD), plasma-  
5                   assisted CVD, sputtering and evaporation, or  
6                   said metal germanium alloy layer is formed by  
7                   first depositing said metal to form a metal  
8                   layer and then doping said metal layer with  
9                   germanium.

1                   4.       The method of Claim 1 further comprising  
2                   forming an optional barrier layer over said  
3                   metal germanium alloy layer prior to step (b),  
4                   wherein said optional barrier layer is removed  
5                   by step (c).

1                   5.       The method of Claim 1 wherein said metal  
2                   germanium alloy layer further includes at least  
3                   one additive selected from the group consisting  
4                   of C, Al, Si, Sc, Ti, V, Cr, Mn, Fe, Co, Ni,  
5                   Cu, Y, Zr, Nb, Mo, Ru, Rh, Pd, In, Sn, La, Hf,  
6                   Ta, W, Re, Ir, Pt, Ce, Pr, Nd, Sm, Eu, Gd, Tb,  
7                   Dy, Ho, Er, Tm, Yb, Lu and mixtures thereof.

1                   6.       The method of Claim 5 wherein said additive is  
2                   C, Al, Si, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu,  
3                   Y, Zr, Nb, Mo, Ru, Rh, Pd, In, Sn, La, Hf, Ta,  
4                   W, Re, Ir, Pt or mixtures thereof

- 1           7.     The method of Claim 6 wherein said additive is  
2            Si, Ti, V, Cr, Ni, Nb, Rh, Ta, Re, Ir or  
3            mixtures thereof.
- 1           8.     The method of Claim 1 wherein said metal  
2            germanium alloy layer contains from about 0.01-  
3            to about 50 atomic % Ge.
- 1           9.     The method of Claim 8 wherein said metal  
2            germanium alloy layer contains from about 0.1  
3            to about 20 atomic % Ge.
- 1           10.    The method of Claim 1 wherein said metal of  
2            said metal germanium alloy layer is Co.
- 1           11.    The method of ~~Claim 4~~ wherein said optional  
2            oxygen barrier layer is composed of TiN.
- 1           12.    The method of ~~Claim 1~~ wherein said silicon-  
2            containing substrate comprises a single crystal  
3            Si, polycrystalline Si, SiGe, amorphous Si, or  
4            a silicon-on-insulator (SOI).
- 1           13.    The method of Claim 2 wherein said pre-  
2            annealing step is carried out using rapid  
3            thermal annealing (RTA).
- 1           14.    The method of Claim 13 wherein said RTA is  
2            carried out at a temperature of from about 350°  
3            to about 450°C for a time period of about 300  
4            seconds or less

- 1           15.     The method of Claim 1 wherein said annealing  
2                 step (b) is carried out by RTA.
- 1           16.     The method of Claim 15 wherein said RTA is  
2                 carried out at a temperature of from about 400°  
3                 to about 700°C for a time period of about 300 -  
4                 seconds or less.
- 1           17.     The method of Claim 1 wherein said remaining  
2                 metal germanium alloy layer is removed  
3                 utilizing a wet etch step that includes the use  
4                 of an etchant that is selective for removing  
5                 said layer.
- 1           18.     The method of Claim 1 wherein said second  
2                 annealing step is carried out by RTA.
- 1           19.     The method of Claim 18 wherein said RTA is  
2                 carried out at a temperature of from about 700°  
3                 to about 900°C for a time period of about 300  
4                 seconds or less.
- 1           20.     The method of Claim 1 wherein said metal is Ni  
2                 and Ni monosilicide is formed after step (b).
- 1           21.     The method of Claim 1 wherein said metal is Co  
2                 and Co monosilicide is formed after step (b).
- 1           22.     The method of Claim 1 wherein said metal is Ti  
2                 and C49 phase of TiSi<sub>2</sub> is formed after step  
3                 (b).

1           23. An electrical contact to a region of a silicon-  
2           containing substrate comprising:

3           a substrate having an exposed region of a  
4           silicon-containing semiconductor material; and

5           a first layer of metal disilicide, wherein said  
6           metal of said disilicide is selected from the  
7           group consisting of Ti, Co and mixtures  
8           thereof, and said substrate and said first  
9           layer are separated by a Si-Ge interlayer.

1           24. An electrical contact to a region of a silicon-  
2           containing substrate comprising:

3           a substrate having an exposed region of a  
4           silicon-containing semiconductor material; and

5           a first layer of Ni monosilicide, wherein said  
6           substrate and said first layer are separated by  
7           a Si-Ge interlayer.

*add*  
*A2*